INNOVATIVE TECHNOLOGY
Summary Report

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Race-Scan EarMic System for Communication in D&D Environments

Deactivation and Decommissioning Focus Area

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INNOVATIVE TECHNOLOGY
Summary Report

Race-Scan EarMic System for Communication in D&D Environments

OST/TMS ID 3129
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Deactivation and Decommissioning Focus Area

Demonstrated at
Los Alamos National Laboratory
Los Alamos, New Mexico

Purpose of this Document

Innovative Technology Summary Reports (ITSR) are designed to provide potential users with the information they need to quickly determine whether a technology would apply to a particular environmental management problem.

The purpose of an ITSR is to describe a technology, system, or process that has been developed and tested with funding from the U.S. Department of Energy's (DOE) Office of Science and Technology (OST). Each report presents the full range of application for the technology, system, or process and the advantages to DOE in terms of system performance, cost, and effectiveness. Most reports include comparisons to baseline and/or competing technologies. Information about commercial availability and technology readiness for implementation is also included. ITSRs are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published ITSRs are available on the OST Web site at http://apps.ost.em.doe.gov/ost/itsrall.html

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SECTION 1
SUMMARY

Technology Summary

The Integrating Contractor Team of the Los Alamos National Laboratory (LANL) Large Scale Demonstration and Deployment Project (LSDDP) demonstrated the Race-Scan EarMic System, which is designed to allow vocal communication between workers within loud, confined zones. Presently, LANL workers communicate with each other in such environments through the use of hand signals and by shouting through respirators. On occasion, workers must also leave the work area in order to communicate with supervision. These forms of communication are ineffective in that they lead to worker frustration, decreased work productivity, and reduced safety.

The results of this demonstration show that the Race-Scan EarMic System will effectively enhance communication in a Decontamination and Decommissioning (D&D) environment. Task efficiency and accuracy improves, since workers are capable of more complete and effective communication among each other and supervisory personnel. Safety improves, since workers can speak more clearly to each other around moving equipment and communication with safety personnel outside the work zone is possible.

Problem

In D&D work requiring anti-contamination clothing and respirators (Personnel Protective Equipment, PPE), communication is inhibited by the respirator. Frequently this same work involves heavy equipment such as forklifts, cranes, air filtration systems, and other noisy machines that further limit the workers' ability to communicate with each other. Furthermore, the confines of the work zone, such as walls and distance, inhibit communication with supervisory and safety personnel outside of the work zone. Effective communication is vital for safety, maximizing task efficiency, reducing worker frustration, and aiding in data recording. Project labor costs and efficiencies are also impacted when communications limitations require that the workers exit the facility, regroup, confirm information, and re-enter the facility in new PPE.

A few communication technologies have been used in these environments, such as throat and bone microphone pickups. These technologies have proven unsuccessful in that workers complain that communication is distorted and the systems are uncomfortable when worn under PPE. Hence, workers must resort to shouting through respirators, using hand signals, and writing signs as the only viable means of communication while working in these areas. For a communications system to prove effective within a D&D environment, the system must:

- Provide clear transmission between workers within the work zone and personnel outside the work zone in the presence of loud machinery
- Be comfortable and easily worn under PPE
- Be easy to operate
- Decrease the time lost due to worker exit and entry
- Be durable.

How It Works

The Race-Scan EarMic System was developed by Race-Scan Communications and is marketed exclusively by Radiation Protection Systems (RPS) for nuclear facility applications. The System was originally developed for use in the NASCAR racing industry for communication between drivers within the loud environment of a racing car and a pit crew. The System is applicable to D&D work since the decibel ranges produced by machines in the work area may reach as high as the inside of a racing car making it difficult for workers to communicate with outside supervision without interference from background noise. Figure 1 shows the EarMic System components. The System includes two earpieces, a push-to-talk switch, and associated wiring. The System currently works with some Ericson and most Motorola two-way radios. Separate earpieces are designed for the right and left ears. The right earpiece contains a

speaker, and the left contains a microphone. The EarMic works by receiving voice sonics inside the ear canal.

Race-Scan Communications offers standard or custom molded earpieces. Standard earpieces are offered in small, medium, and large. Custom earpieces provide noise reduction up to 40 dBA while allowing clear communication without interference from background noise. Somewhat less noise reduction may be expected using standard earpieces since they will not fit perfectly within the ear. The custom molded earpieces are recommended by the manufacturer to maximize noise reduction and to insure that they remain in place. All EarMic System equipment is worn under PPE, minimizing worker interference and preventing equipment contamination.

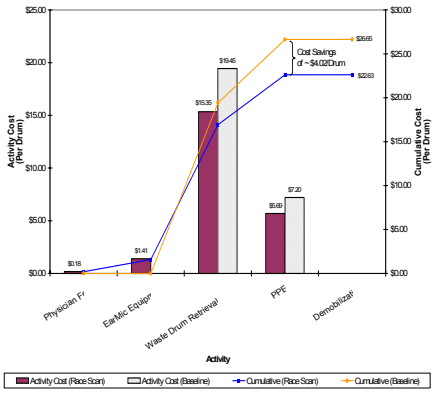

Figure 1 – Race-Scan EarMic System Components

Demonstration Summary

In this demonstration, the EarMic System was used in place of the typical means of communication for two ongoing D&D operations at LANL. These operations were (1) waste drum retrieval from an above ground berm and (2) waste crate venting carried out within a PermaCon structure. In both operations, communication between the workers within the work zone is limited by loud noise produced by equipment. In the PermaCon structure, the walls of the structure limit communication between workers and outside supervision.

Results

In both operational phases of the demonstration, it was observed that operations proceeded more smoothly and that workers spent significantly less time and effort communicating with each other and supervision. This was mainly due to the fact that workers were able to communicate with each other without having to move from their workstations. No limitations on transmission clarity were noted due to the walls of the PermaCon for the waste box sampling phase of the demonstration. The most significant result of the demonstration was that efficiencies in these operations improved from 20 to 40%.

All workers involved with both phases of the demonstration were impressed with the transmission clarity, ease of use and comfort of the EarMic System and look forward to using it in the future. In addition, they felt the quality of communication between all workers in each phase of the demonstration was superior to that of the baseline technology. By providing clear, direct communication with medical and safety personnel, all workers believed safety would be enhanced by use of the System.

Most workers felt that the standard sized earpieces were somewhat comfortable despite the fact that a few had problems getting the earpieces correctly inserted. All workers believed the earpieces provided adequate reduction of background noise while allowing clear transmission. According to all workers, the EarMic System was very simple to operate within PPE. Most workers were satisfied with the performance of the System overall. Some thought the performance would be improved by using custom ear molds for added comfort, better noise reduction, and to better secure the earpieces within the ear.

Benefits

- Increases worker safety through effective communication
- Improves efficiency by decreasing miss-communication among workers, data takers, and supervisors
- Improves efficiency by lowering worker stress levels
- Improves efficiency by allowing clear communication with supervisors outside the radiological area and reducing unnecessary exits
- Reduces noise exposure by as much as 40 dBA

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Other

All published Innovative Technology Summary Reports are available on the Office of Science and Technology (OST) Web site at http://ost.em.doe.gov under “Publications.” The Technology Management System (TMS), also available through the OST Web site, provides information about OST programs, technologies, and problems. The OST reference number for the Race-Scan EarMic System demonstration is #3129.

The Los Alamos LSDDP website address is: http://www-emtd.lanl.gov/LSDDP/DDtech.html.

SECTION 2
TECHNOLOGY DESCRIPTION

Overall Process Definition

The overall objective of the demonstration was to evaluate the Race-Scan EarMic System's ability to enhance communication in environments where the combination of Personnel Protective Equipment and loud machinery inhibits communication to the point that safety and efficiency are compromised. To adequately demonstrate the Race-Scan EarMic System, two ongoing LANL activities were chosen. The first involved a well-established waste retrieval operation, and the second focused on a fairly new waste crate gas sampling operation.

PHASE I – Waste Retrieval

Phase I of the demonstration was a waste retrieval operation where waste drums and crates are removed from an above ground earth-bermed storage site located at the Transuranic Waste Inspectable Storage Project (TWISP) at LANL. Figure 2 shows this work site. At this site, waste drums and crates are lifted from the berm using a crane. The retrieved drums and crates are then cleaned and monitored by workers. Five workers are used for this activity: one crane operator, a waste drum rigger, and three drum retrieval workers responsible for drum movement, cleanup, and survey. Each worker wears a powered air purifying respirator, coveralls, a hard hat and ear plugs. The noise level at this particular site reaches as high as 100 dBA while the crane is revving. The workers on the ground communicate with the crane operator through hand signals and each other by shouting through their respirator. A supervisor outside the work zone communicates with the crane operator using a two-way radio system. However, radio communication is not possible while the crane is revving due to the noise. For the supervisor to contact the workers on the ground, all work must stop, and the workers must walk to the edge of the work zone. If the supervisor is out of view, he may interrupt the operator on the radio, forcing him to leave the crane, gather the workers, and convey the message. Worker productivity and project costs are affected, as time is lost to workers trying to communicate with people inside and outside the work zone. This in turn compromises worker safety since more time must be spent in the area, and the potential for heat stress is increased.

Figure 2 – Waste Drum Retrieval Site

PHASE II – Waste Crate Sampling

Phase II of the demonstration focused on a waste crate sampling operation that is carried out within a PermaCon enclosure. In this operation, two workers drill sample ports into each waste crate while an industrial health technician (IHT) and a radiological control technician (RCT) monitor the activities. A supervisor remains outside the walls of the PermaCon to pass information to the workers, as needed. Each worker wears a full-face respirator, coveralls and earplugs. The workers within the PermaCon typically communicate with each other through shouting, hand signals, and writing messages on clipboard-sized white marker boards. This is a fairly new operation at LANL, and contact between the workers inside the PermaCon and supervisors outside is critical for worker training and data exchange purposes. Figure 3 shows this work site.

Loud noise is produced within the PermaCon by the ventilation fan and various other cutting and drilling equipment. The noise level within the PermaCon due to all machinery can reach as high as 95 dBA. Daily procedures outline the specific tasks for the day. If an unplanned situation develops that cannot be resolved through communication with supervision outside the PermaCon, the workers must exit to resolve the issue. For each unanticipated exit, the workers must survey for contamination, remove their PPE, meet with supervision, and then re-suit in clean PPE to resume operation. As a result, project costs increase due to the additional man-hours and supplies required. In the case of this demonstration, four workers would exit the PermaCon to obtain the needed information. Historical information on this specific job indicates that workers exit the PermaCon, on average, three times per week due to the inability of the supervisor outside to pass needed information to workers on the inside.

Figure 3 – Crate Sampling within PermaCon

SECTION 3
PERFORMANCE

Demonstration Plan

A test plan was developed and approved to objectively evaluate the Race Scan EarMic System for both phases of the demonstration (reference 1). Four EarMic Systems were provided by RPS for use in this demonstration. The first day of Phase I and II of the demonstration consisted of watching and documenting the workers as they performed their respective tasks without EarMics. This constituted the baseline for the demonstration. The following day, the same workers were asked to perform their normal work activities using the Race-Scan EarMic System in place of the baseline technology. Each worker was dressed in PPE consisting of coveralls and a full-face respirator. Equipment for the Race-Scan EarMic System was worn under the workers' PPE. (For these demonstrations, standard Race-Scan earpieces were used instead of custom fitted pieces.)

In Phase I of the demonstration, the crane operator, waste drum rigger, and two drum retrieval workers used EarMic Systems. The supervisor, outside the work zone, maintained contact with the workers by using a radio without an earpiece. For Phase II of the demonstration, three workers inside the PermaCon, and the supervisor outside the PermaCon wore an EarMic System.

At the conclusion of the demonstration, each worker wearing the Race-Scan EarMic System was asked to evaluate the System in the following areas:

- Clarity
- Comfort
- Ease of use
- Safety
- Improved task efficiency
- Interest in continued use
- Noise reduction

Results

In both phases of the demonstration, it was noted that operations proceeded more smoothly and that workers expended significantly less time and effort communicating with each other and supervision on the outside. The enhanced operation is largely credited to the improved communication among workers without the necessity of leaving their workstations. The Race-Scan EarMic System proved to be most beneficial in the waste drum-sampling phase of the demonstration by allowing continuous communication with supervision outside the PermaCon. Such communication is necessary and yet, often hindered by the PermaCon walls. Each of the test objectives is addressed individually below.

PHASE I – Waste Drum Retrieval

The baseline for Phase I of the demonstration included many instances where the operator left the crane to talk to the workers. Workers spent time talking to the supervisor at the edge of the work area. Thirty-two drums were excavated from the site in 95 minutes.

On the second day, four personnel were provided with EarMic Systems for the same drum retrieval activities: the operator, rigger, and two drum retrieval workers. The foreman used a radio without earpieces to maintain radio contact with the workers from outside the work zone. During the demonstration it was noted that the operator never left the crane to talk with the other workers. The crane operator was able to ask the rigger questions about specific waste drums such as which one to move next or the condition of the drum to be lifted. Both drum retrieval workers were able to ask the operator to manipulate a waste drum in a particular fashion or to place it in a specific location to allow each to be cleaned and monitored. Thirty-two drums were retrieved from the site in 75 minutes.

Table 1, below, summarizes the results of the baseline and EarMic demonstrations for Phase I. A timesavings of 20 minutes was observed by using the EarMic System in this established and routine operation. This represents a reduction in time by approximately 21 percent.

Communication Option	Units Processed	Start Time	Finish Time	Time (minutes)
Baseline Technology	32	10:00	11:35	95
Race-Scan EarMic System	32	10:15	11:30	75
Time Difference				20

Table 1 – Waste Drum Retrieval Results

To obtain additional information regarding the performance of the RaceScan EarMic System, each worker was asked to evaluate the System compared to the baseline. The workers were asked to numerically rate the results on a scale of 1 to 5, with 1 being the baseline rating, 2 through 4 being better than the baseline, and 5 being superior to the baseline. A brief discussion of the survey's results and a table summarizing the worker responses for the Phase I investigation are shown in Table 2.

- **Comfort**
  All workers felt that the standard sized earpieces were comfortable.

- **Clarity**
  All workers felt the quality of communication superior to that of the baseline technology. The EarMic System allowed the workers inside the work zone to easily communicate with each other in the presence of the crane without leaving their workstations. The operator was able to communicate with the drum retrieval workers without dismounting the crane.

- **Ease of Use**
  All workers felt the EarMic System was very simple to operate within PPE.

- **Safety**
  The comparison between the baseline and the EarMic System was based on opinions and ratings by the workers concerning how they felt the System would enhance safety. All workers felt the major safety advantage would be that it allows them to communicate more effectively in the presence of heavy equipment.

- **Improved task efficiency**
  All work activities making use of the EarMic System proceeded more smoothly compared to the baseline activities. The time required to process 32 drums for the baseline and using the EarMic System can be seen in Table 1. Since the workers were able to communicate with each other without leaving their work stations, 20 minutes were saved in the excavation of 32 drums.

- **Interest in continued use**
  All workers in Phase I of the demonstration were interested in continued use of the EarMic System.

- **Noise Reduction**
  All workers thought the standard earpieces provided adequate noise reduction against the crane, allowing the workers to speak to each other while the crane was revving.

	Operator	Rigger	Ground Worker 1	Supervisor*	Average
Comfort	5	5	5	NA	5.0
Clarity	5	5	5	NA	5.0
Ease of use	5	4	4	NA	4.33
Safety	5	5	5	NA	5.0
Improve task efficiency	5	5	5	NA	5.0
Interest in continued use	5	5	5	NA	5.0
Noise reduction	5	5	5	NA	5.0
SUBTOTAL(baseline = 15)	35	34	34	NA	34.33

*Supervisor could not comment on comfort, clarity, and ease of use since he did not use the earpieces in conjunction with the radio to communicate.

Table 2 – Worker Responses for Phase I

PHASE II – Waste Crate Sampling

During the Phase II baseline demonstration, communication consisted of shouting between the workers within the PermaCon and shouting at the supervisor outside of the PermaCon. There was also an instance where a worker wrote on a sign to communicate with the supervisor. During the demonstration it was obvious that the workers on the inside as well as the supervisor on the outside were frustrated by communication difficulties. It took the crew 100 minutes to sample one crate.

On the second day of the Phase II demonstration, three workers within the PermaCon, and a supervisor all wore the EarMic System. The EarMic System allowed the workers to communicate with each other and the supervisor outside the PermaCon clearly. By using the EarMic System, the crew was able to sample two crates in 110 minutes.

Table 3, below, summarizes the results of the baseline and EarMic demonstrations for Phase II. A time savings of 45 minutes per crate was observed by using the EarMic System, a fairly new operation. This represents a reduction in time of 45 percent.

	Units Processed	Start Time	Finish Time	Time (minutes)	Time Per Crate (minutes)
Baseline Technology	1	9:35	11:15	100	100
Race-Scan EarMic System	2	9:15	11:05	110	55
Time Difference					45

Table 3 – Waste Crate Sampling Results

Again, each worker was asked to evaluate the Race-Scan EarMic System versus the baseline operation. The following discussion and table summarize the responses of those workers involved with the Phase II operation.

- **Comfort**
  Most workers felt that the standard sized earpieces were somewhat comfortable, although a few complained that they began to hurt toward the end of the work period.

- **Clarity**
  All workers felt the quality of communication in each phase of the demonstration was superior to that of the baseline technology. The EarMic System allowed the workers inside the PermaCon to easily communicate with each other as well as with the supervisor outside. There was no limitation on transmission clarity noted due to the walls of the PermaCon.

- **Ease of Use**
  A few workers had problems getting the earpieces in correctly. Most workers were satisfied with the performance of the System, although some thought the performance would be improved by using custom ear molds for added comfort, better noise reduction, and to better secure the earpieces within the ear. All workers felt the EarMic System was very simple to operate within PPE.

- **Safety**
  All workers thought safety would be enhanced by use of the System since direct communication with medical and safety services outside the PermaCon is possible.

- **Improved task efficiency**
  All work activities went more smoothly than the baseline activities. The time to sample each box for the baseline and using the EarMic System can be seen in Table 3.

- **Interest in continued use**
  The workers plan on implementing the Race-Scan EarMic System into their operation immediately.

- **Noise Reduction**
  All workers thought the standard earpieces provide adequate noise reduction against the ventilation fan and power tools. This allowed them to communicate with each other and the supervisor outside the PermaCon without noise interference.

	Worker 1	Worker 2	Worker 3	Supervisor	Average
Comfort	5	4	4	5	4.5
Clarity	5	4	5	5	4.75
Ease of Use	5	5	4	4	4.5
Safety	5	5	5	5	5.0
Task efficiency	5	5	5	5	5.0
Interest in continued use	5	5	5	5	5.0
Noise reduction	5	5	5	5	5.0
SUBTOTAL(baseline = 15)	35	33	33	34	33.75

Table 4 – Worker Responses for Phase II

SECTION 4
TECHNOLOGY APPLICABILITY AND ALTERNATIVES

Competing Technologies

The competing technologies include other bone and throat communications systems and camera/microphone systems. The major difference between these systems and the Race-Scan EarMic System is that the EarMic System detects ear sonics rather than bone and throat vibrations. The bone and throat systems have been used at LANL as well as at other DOE sites, with unfavorable results. Major complaints are that they are uncomfortable while being worn under PPE and transmissions are unclear and described as a constant gargling sound.

Technology Applicability

The Race-Scan EarMic System is applicable to work in radioactive environments where heavy equipment is used and the confinement zone limits communication from people outside the area.

Patents/Commercialization/Sponsor

Race-Scan Communications holds the patent for the EarMic System. RPS is the exclusive distributor of the Race-Scan EarMic System for the nuclear industry.

SECTION 5
COST

Methodology

The objective of the cost analysis was to provide interested parties with a cost estimate for implementation of the Race-Scan EarMic System at a DOE site with an intent to facilitate estimation of potential savings in other applications. This cost estimate calculates the cost associated with both operations carried out in this demonstration for both the baseline and Race Scan options for a period of one year. These operations are the waste drum retrieval operation and the waste crate sampling operation as carried out at LANL. In both operations, a total of five workers are present. In each operation, there is a supervisor outside the work zone that maintains radio communication with the workers inside the zone. Although, the number of workers that participated in each operation is the same, the worker classifications for both operations differ. For this cost estimate it is assumed that five complete EarMic Systems will be purchased , even though the supervisor outside the work zone will not utilize an ear-piece/switch set, which can be kept as a spare.

The baseline and EarMic technologies were demonstrated under controlled conditions, which facilitated observation of the work procedures and the typical duration of these procedures. To approach realistic implementation costs, additional assumptions were invoked regarding the cost comparison with the baseline technology. This cost analysis compares both technologies based on a unit processing costs.

The cost estimates are based on a full year of operation at the demonstration locations with and without the EarMic System. A unit cost was developed from the annual costs. Key assumptions for the cost estimate/cost comparison are listed below. Other assumptions and details about the cost analysis are presented in Appendix B.

1. It is assumed that a work team consists of five workers, four workers inside the work zone, and a supervisor outside the work zone.
2. Four hours are required to have earmolds made by a physician.
3. A DOE site, such as LANL, purchases all equipment necessary for deployment in a radioactive D&D operation such as the Phases I or II of this demonstration.
4. A one-year operation was estimated using a work schedule of four days per week and 50 weeks per year. Phase I workers are assumed to spend approximately 1.5 hours in the work zone per day while Phase II personnel work two, 2.5-hour shifts per day.
5. No overhead factors were applied to other direct costs.
6. Fully burdened labor rates for LANL personnel were used in the estimate.
7. In order to calculate per-drum and per-crate costs, the initial costs for the EarMic equipment are divided by the estimated number of units to be processed in one work year.

Cost Analysis

To develop an estimate for implementation, a unit cost basis was chosen as the most instructive approach for representation of the performance of the systems. Activities were grouped under higher level work titles per the work breakdown structure shown in the Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary (HTRW RA WBS) (U.S. Army Corps of Engineers, 1996).

Tables 5 and 6 provide a comparison of the productivity and costs associated with the Race Scan technology and those of the baseline for Phase I and Phase II, respectively. The time per unit was determined from the demonstrations. The hours worked per year are based on the assumption that a workday consists of 1.5 hours for Phase I and two, 2.5-hour shifts for Phase II. A workweek consists of 4 days, and a work year consists of 50 weeks. By dividing the hours worked in a year by the amount of

time required per unit, the number of units processed per year can be determined. Annual subtotals were calculated and shown in Appendix B. By dividing the annual costs by the number of units processed in a year, the cost per unit is determined.

Figures 4 and 5 summarize the results of the cost analysis for Phase I and Phase II, respectively. They compare the unit costs obtained by using the Race Scan EarMic System to those associated with the baseline. The bars indicate the cost of each individual activity on a cost-per-unit basis, and the line sums the cost.

Cost Conclusions

The cost estimate calculates a reasonable cost for implementation of the Race Scan EarMic System at a DOE site. Using the demonstration costs as a basis, costs were developed for mobilization, sampling and testing, and demobilization. The Phase I scope of work represents a well-established work routine, and costs per unit were based on 300 total hours of drum retrieval activities in one year and the demonstrated time per unit. The Phase II scope of work represents a fairly new procedure with costs per unit based on 1000 hours of crate sampling per year and the demonstrated time per unit.

The time saved by using the EarMic System during Phase I operations accounts for a cost savings of approximately $4.02 per drum, or 15 percent. By implementing the EarMic System in Phase II operations, a cost savings of approximately $376 per crate was observed. This represents a cost reduction of approximately 44 percent.

	Time Per Drum (Hours)	Hours Worked Per Year	Drums Processed Per Year	Annual Subtotal	Cost Per Drum
Race Scan	0.0391	300	7680	$173,761	$22.63
Baseline	0.0495	300	6063	$161,585	$26.65

Table 5 – Summary of Phase I Productivity and Costs

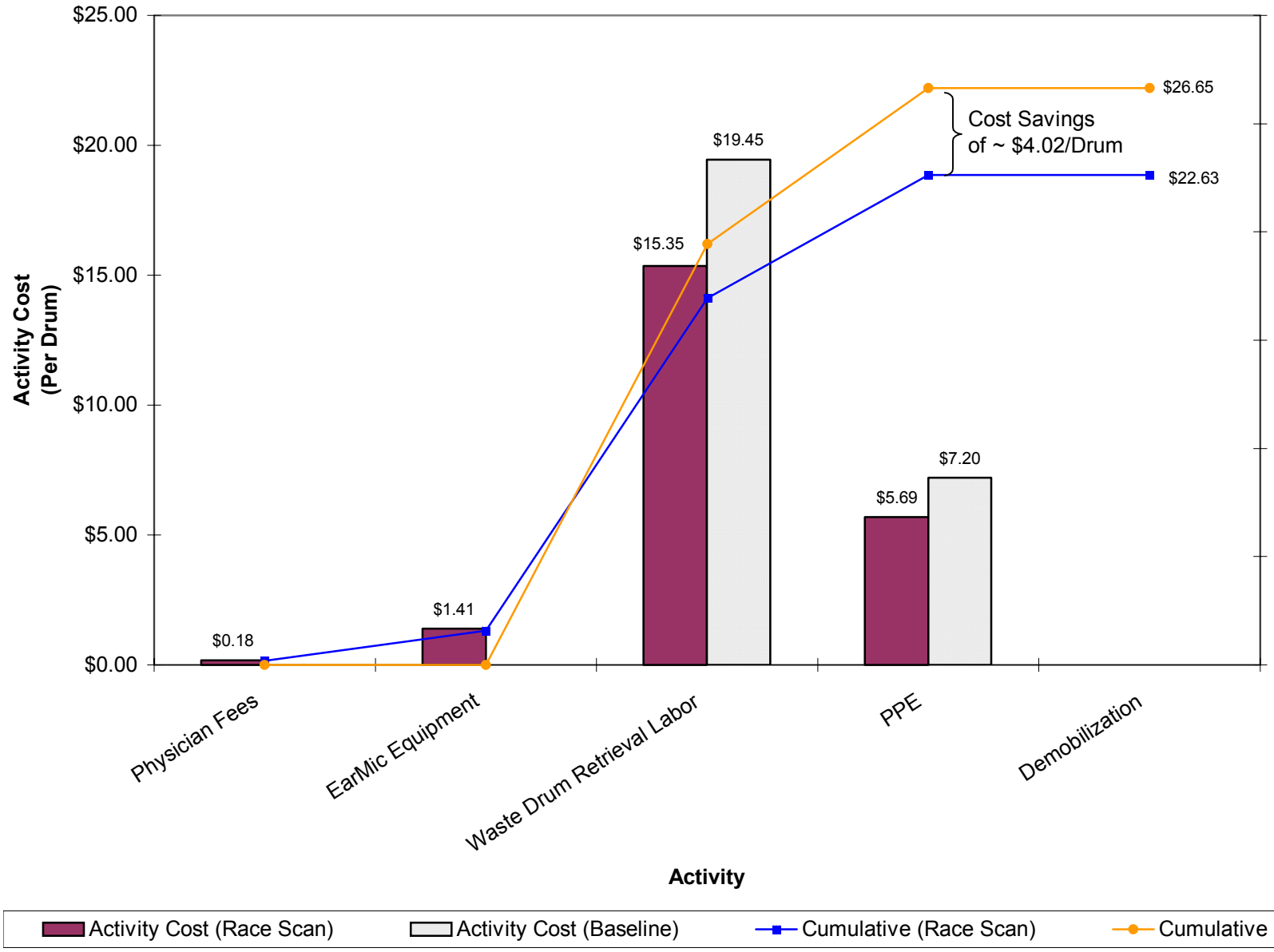

Figure 4 – Unit Costs for Race Scan EarMic System vs. Baseline for Phase I

	Time Per Crate (Hours)	Hours Worked Per Year	Crates Processed Per Year	Annual Subtotal	Cost Per Crate
Race Scan	0.917	1000	1090	$528,953	$485.28
Baseline	1.667	1000	600	$516,477	$860.79

Table 6 – Summary of Phase II Productivity and Costs

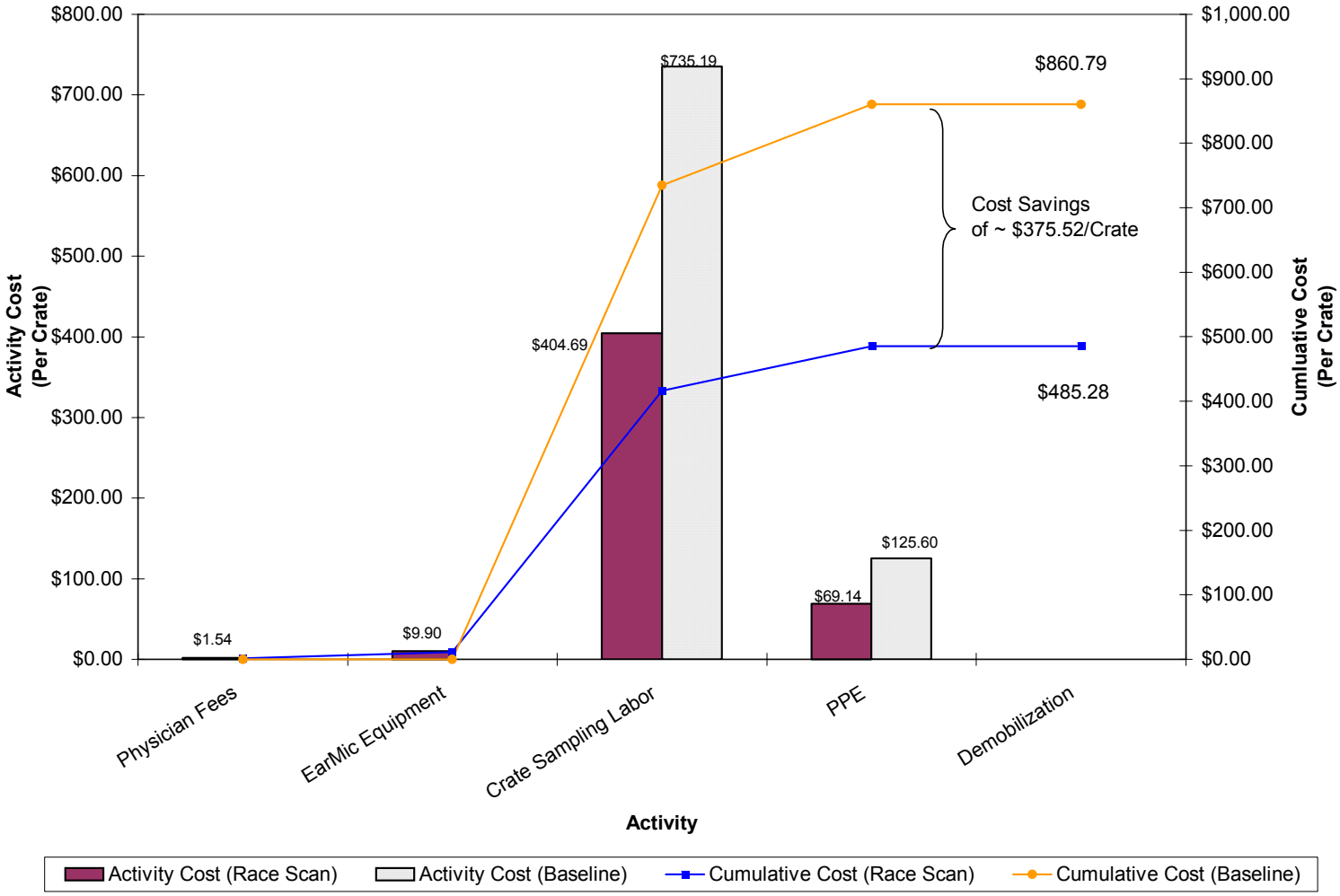

Figure 5 – Unit Costs for Race Scan EarMic System vs. Baseline for Phase II

SECTION 6
REGULATORY AND POLICY ISSUES

Regulatory Considerations

Since the Race-Scan EarMic System is worn when performing D&D activities, there are no regulatory requirements that apply. However, some evaluation criteria typically used to evaluate technology alternatives by the CERCLA process, such as protection of human health and community acceptance, are briefly discussed below.

Safety, Risks, Benefits, and Community Reaction

Worker Safety

No special worker safety considerations were required for operation of the Race-Scan EarMic System. Additionally, worker safety is greatly improved given that the EarMic System allows workers to communicate with each other in the presence of heavy equipment. This System also allows for communication with emergency services outside the work zone. Less time may be needed in a radiological area since less time will be lost due to workers trying to communicate with each other.

Community Safety

Community safety is not adversely affected by operation of the Race-Scan EarMic System.

Environmental Impact

There is no negative environmental impact associated with use of the Race-Scan EarMic System. Less waste will be generated since workers' need to exit the radiological area will be reduced.

Socioeconomic Impacts and Community Reaction

There are no socioeconomic impacts associated with the Race-Scan EarMic System. Community reaction is likely to be positive given that the EarMic System may enhance worker safety.

SECTION 7
LESSONS LEARNED

Implementation Considerations

The Race-Scan EarMic System is commercially available and is marketed through RPS. The System can be purchased with custom molded earpieces, which improve noise reduction, are more comfortable, and fit better within the ear. Suggestions from other sites using the EarMic System are as follows:

- Fitted earpieces are recommended.
- If standard earpieces must be worn, they should be secured within the ear by wearing a skullcap or taping.
- Measures should be taken to tape or attach the push-to-talk switch and the radio on a safe area of the body to prevent snagging.
- The earpieces should be stored in a container when not in use since the associated wiring may be easily damaged.
- Distortion can be minimized if workers do not shout while wearing the System.
- Some interference is possible while working around machinery.

Technology Limitations and Needs for Future Development

Since workers often shift between work assignments, it would be beneficial if the user could have the EarMics recycled saving the cost of the associated wiring.

Technology Selection Considerations

Considerations for selection of this technology include:

- Whether the operation is well developed and routine (perhaps a 20% efficiency improvement) or a non-routine operation requiring routine coordination (perhaps a doubling of productivity)
- Compatibility with host site security restrictions.

APPENDIX A

REFERENCES

(1) IT Corporation, 1999, Test Plan for LANL Race-Scan EarMic System Demonstration

(2) Headquarters, United States Army Corps of Engineers, 1996, Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary

APPENDIX B

COST DETAILS

Basis of Estimated Cost

The cost estimate compares the costs associated with implementing Race-Scan EarMic Communications Systems verses those of the baseline technology for both phases of the demonstration carried out at LANL. The actual demonstration costs incurred at LANL formed the basis of the cost estimate and were extrapolated to determine annual expenses.

In the well-established waste retrieval phase of the demonstration, 32 drums were processed in 95 minutes. Only 75 minutes were required to process 32 drums when using the Race-Scan EarMic System. Thus, by implementing the EarMic System, 20 minutes were saved.

In the waste crate-sampling phase of the demonstration, a single crate was processed in 140 minutes with the baseline technology, while two crates were processed in 110 using the Race-Scan EarMic System. Thus, the work efficiency doubled in 30 minutes less time.

Other assumptions are as follows:

1. It is assumed that a work team consists of five workers, four workers inside the work zone, and a supervisor outside the work zone.
2. Four hours are required to have earmolds made by a physician.
3. A DOE site, such as LANL, purchases all equipment necessary for deployment in a radioactive D&D operation such as the Phases I or II of this demonstration.
4. A one-year operation was estimated using a work schedule of four days per week and 50 weeks per year. Phase I workers are assumed to spend approximately 1.5 hours in the work zone per day while Phase II personnel work two, 2.5-hour shifts per day.
5. Other costs include:
    a. Donning PPE takes 15 minutes per day (50 hrs/yr)
    b. Doffing PPE takes 20 minutes per day (67 hrs/yr)
    c. PPE costs consist of the Coverall, Hood, Overboots, Gloves and Gloveliners, and laundry fees for a cost of $31.60 per unit.
    d. Respirator cartridges cost $8.00 each
    e. The monthly respirator servicing fee is $250.00
6. Other laborers provided by the DOE site to accomplish each operation including a site supervisor, site health physics supervisor, site safety officer, and site radiation control technician, are not included since there is no difference in their respective job functions and duration for both options.
7. No overhead factors were applied to other direct costs.
8. Fully burdened labor rates for LANL personnel were used in the estimate.
9. The Race Scan EarMic system consists of the Ericson Radios, custom EarMics, radio antennas, chargers, belt clips, and batteries. The cost is $2,159/each.
10. In order to calculate per-drum and per-crate costs, the initial costs for the EarMic equipment are divided by the estimated number of units to be processed in one work year.

Activity Descriptions

The scope of each work breakdown structure (WBS) element, computation of production rates, and assumptions (if any) for each work activity are described in this section.

Mobilization and Preparatory Work (WBS 33.1.01)

There are no mobilization costs associated with the baseline technology. Mobilization and preparatory work for the Race Scan technology involves the acquisition of System equipment as well as the associated physician visits. Physician visits to obtain ear molds are assumed to require 4 hours per person and are calculated using individual wage rates. EarMic System equipment costs total approximately $2,159 per system, as quoted for the LANL Ericson radios. Note that EarMic systems can be purchased for $1,389 each using conventional Motorola radios. Broken down over the period of one work year, each system costs approximately $10.80 per day.

Submittals/Implementation Plans: Plans were assumed to be complete prior to the start of the work. No permits were required.

Monitoring, Sampling & Testing (WBS 33.1.02)

Monitoring, sampling and testing costs take into account PPE costs as well as all labor costs associated with the day's activities. These are characteristic of both the Race Scan and baseline technologies. Labor costs include the time required to enter and exit the work zone in addition to the time required to perform the daily task. Based on the results for each demonstration, it is assumed that an average time of 15 minutes is required to don PPE and enter the work zone while an average of 20 minutes is required to doff PPE and exit. The time required for each worker to put on an EarMic System was less than a minute and thus, will not be considered in this cost estimate.

Decontamination (WBS 33.1.02)

Since all EarMic equipment is worn under workers' PPE it is assumed that the System components will not require decontamination. It is also assumed that there are no decontamination costs associated with the baseline technology.

Demobilization (WBS 33.1.21)

There are no demobilization costs associated with the baseline or Race Scan technology.

Equipment Cost

The Race-Scan EarMic System equipment was borrowed free of charge for the purposes of this demonstration. During the demonstration, standard earpieces and Motorola two-way radios were used. The manufacturer recommends using the custom-molded earpieces for better comfort and increased hearing protection. The price difference between standard and custom earpieces is the labor cost for each worker to have ear molds made by a physician and the physician cost. According to a physician in the area, it takes approximately four hours per worker to make the ear molds and the physician cost is $50.00 per worker. With regards to the radio, LANL prefers to use Ericson radios as opposed to the Motorola models. The cost of each System has been quoted at $2,159.00. This includes two custom-molded earpieces, push-to-talk switch, an Ericson radio, antenna, single charger, high capacity batteries, and a metal belt clip. The lifetime of the EarMic System is expected to be 1 year.

The baseline and EarMic System require PPE to fulfill the RWP requirements. This cost includes the daily cost for PPE, respirator cleaning costs, and laundry costs. Cost data for PPE were found in a Lab Safety Supply catalog. UniTech estimated the cost for laundry service, including transportation, as $4.00 per unit. Each unit consists of coveralls, shoe covers and gloves.

Each respirator must be sent to E-ET at LANL for cleaning, then to ESH-5 for assembly and testing once per month. Personnel associated with these groups at LANL state the cost to process each respirator is approximately $250.00.

Cost Estimate Summary

The cost analysis details for the Phase I demonstration are summarized in Tables B-1 and B-2 while those for the Phase II demonstration are found in Tables B-3 and B-4. In both estimates, a cost savings is projected in application of the Race Scan EarMics.

Table B-1: Baseline Cost For Phase I

TITLE	LABOR	LABOR QUANTITY	EQUIPMENT	UNIT OF MEASURE	UNIT COST	QUANTITY	DAILY SUBTOTALS	ANNUAL SUBTOTALS
Mobilization and Preparatory Work (WBS 33.1.01)							**$0.00**	**$0.00**
							$0.00	$0.00
							$0.00	$0.00
Monitoring, Sampling & Testing (WBS 33.1.02)							**$807.92**	**$161,584.62**
Waste Drum Retrieval							*$589.52*	*$117,904.62*
	Technical Staff Member	4	Drum Production	Hour	$48.00	300.00	$288.00	$57,600.00
		4	Don PPE and enter work zone	Hour	$48.00	50	$48.00	$9,600.00
		4	Doff PPE and exit work zone	Hour	$48.00	66.75	$64.08	$12,816.00
	Supervisor	1		Hour	$90.86	417.00	$189.44	$37,888.62
PPE							*$218.40*	*$43,680.00*
			Tyvek Coverall	Ea.	$6.00	800	$24.00	$4,800.00
			Tyvek Hood	Ea.	$0.84	800	$3.36	$672.00
			Latex Overboots	Pair	$3.30	800	$13.20	$2,640.00
			PVC Overboots	Pair	$12.15	800	$48.60	$9,720.00
			Glove Liners	Pair	$3.76	800	$15.04	$3,008.00
			Gloves N-DCR	Pair	$0.20	800	$0.80	$160.00
			Gloves Nitril/Latex	Pair	$1.35	800	$5.40	$1,080.00
			Respirator Cartridge	Set	$8.00	800	$32.00	$6,400.00
			Respirator Cleaning	Ea.	$250.00	48	$60.00	$12,000.00
			PPE Laundry Service Fee	Unit	$4.00	800	$16.00	$3,200.00
Demobilization (WBS 33.1.21)							**$0.00**	**$0.00**
							$0.00	$0.00
							$0.00	$0.00
TOTAL COST:							**$807.92**	**$161,584.62**

Table B-2: Race-Scan EarMic System Estimated Implementation Cost For Phase I

TITLE	LABOR	LABOR QUANTITY	EQUIPMENT	UNIT OF MEASURE	UNIT COST	QUANTITY	DAILY SUBTOTALS	ANNUAL SUBTOTALS
Mobilization and Preparatory Work (WBS 33.1.01)							**$60.88**	**$12,176.44**
Physician Fees							*$6.91*	*$1,381.44*
	Technical Staff Member	4		Hour	$48.00	4	$3.84	$768.00
	Supervisor	1		Hour	$90.86	4	$1.82	$363.44
	Physician			Lump	$50.00	5	$1.25	$250.00
Ear Mic Equipment							*$53.98*	*$10,795.00*
			Ericson Radio (Model M-RK)	Lump	$1,048.00	5	$26.20	$5,240.00
			Custom Ear Mics/PTT Switch/Cable	Lump	$925.00	5	$23.13	$4,625.00
			Antenna	Lump	$10.00	5	$0.25	$50.00
			Single Charger	Lump	$60.00	5	$1.50	$300.00
			Metal Belt Clip	Lump	$21.00	5	$0.53	$105.00
			High Capacity Batteries	Lump	$95.00	5	$2.38	$475.00
Monitoring, Sampling & Testing (WBS 33.1.02)							**$807.92**	**$161,584.62**
Waste Drum Retrieval							*$589.52*	*$117,904.62*
	Technical Staff Member	4	Drum Production	Hour	$48.00	300	$288.00	$57,600.00
		4	Don PPE and enter work zone	Hour	$48.00	50	$48.00	$9,600.00
		4	Dof PPE and exit work zone	Hour	$48.00	66.75	$64.08	$12,816.00
	Supervisor	1		Hour	$90.86	417.00	$189.44	$37,888.62
PPE							*$218.40*	*$43,680.00*
			Tyvek Coverall	Ea.	$6.00	800	$24.00	$4,800.00
			Tyvek Hood	Ea.	$0.84	800	$3.36	$672.00
			Latex Overboots	Pair	$3.30	800	$13.20	$2,640.00
			PVC Overboots	Pair	$12.15	800	$48.60	$9,720.00
			Glove Liners	Pair	$3.76	800	$15.04	$3,008.00
			Gloves N-DCR	Pair	$0.20	800	$0.80	$160.00
			Gloves Nitril/Latex	Pair	$1.35	800	$5.40	$1,080.00
			Respirator Cartridge	Set	$8.00	800	$32.00	$6,400.00
			Respirator Cleaning	Ea.	$250.00	48	$60.00	$12,000.00
			PPE Laundry Service Fee	Unit	$4.00	800	$16.00	$3,200.00
Demobilization (WBS 33.1.21)							**$0.00**	**$0.00**
							$0.00	$0.00
							$0.00	$0.00
TOTAL COST:							**$868.81**	**$173,761.06**

Table B-3: Baseline Cost For Phase II

TITLE	LABOR	LABOR QUANTITY	EQUIPMENT/LABOR DESCRIPTION	UNIT OF MEASURE	UNIT COST	QUANTITY	DAILY SUBTOTALS	ANNUAL SUBTOTALS
Mobilization and Preparatory Work (WBS 33.1.01)							**$0.00**	**$0.00**
							$0.00	$0.00
							$0.00	$0.00
Monitoring, Sampling & Testing (WBS 33.1.02)							**$2,582.38**	**$516,476.76**
Crate Sampling							*$2,205.58*	*$441,116.76*
	Technical Staff Member	2	Crate Production	Hour	$48.00	1000.00	$480.00	$96,000.00
		2	Don PPE and enter work zone	Hour	$48.00	100	$48.00	$9,600.00
		2	Doff PPE and exit work zone	Hour	$48.00	133.50	$64.08	$12,816.00
	Health Physicist	1	Crate Production	Hour	$80.00	1000.00	$400.00	$80,000.00
		1	Don PPE and enter work zone	Hour	$80.00	100	$40.00	$8,000.00
		1	Dof PPE and exit work zone	Hour	$80.00	133.00	$53.20	$10,640.00
	Supervisor	1	Crate Production	Hour	$90.86	1000.00	$454.30	$90,860.00
		1	Don PPE and enter work zone	Hour	$90.86	100.00	$45.43	$9,086.00
		1	Dof PPE and exit work zone	Hour	$90.86	133.00	$60.42	$12,084.38
	Supervisor	1		Hour	$90.86	1233.00	$560.15	$112,030.38
PPE							*$376.80*	*$75,360.00*
			Tyvek Coverall	Ea.	$6.00	1600	$48.00	$9,600.00
			Tyvek Hood	Ea.	$0.84	1600	$6.72	$1,344.00
			Latex Overboots	Pair	$3.30	1600	$26.40	$5,280.00
			PVC Overboots	Pair	$12.15	1600	$97.20	$19,440.00
			Glove Liners	Pair	$3.76	1600	$30.08	$6,016.00
			Gloves N-DCR	Pair	$0.20	1600	$1.60	$320.00
			Gloves Nitril/Latex	Pair	$1.35	1600	$10.80	$2,160.00
			Respirator Cartridge	Set	$8.00	1600	$64.00	$12,800.00
			Respirator Cleaning	Ea.	$250.00	48	$60.00	$12,000.00
			PPE Laundry Service Fee	Unit	$4.00	1600	$32.00	$6,400.00
Demobilization (WBS 33.1.21)							**$0.00**	**$0.00**
							$0.00	$0.00
							$0.00	$0.00
TOTAL COST:							**$2,582.38**	**$516,476.76**

Table B-4: Race-Scan EarMic System Estimated Implementation Cost For Phase II

TITLE	LABOR	LABOR QUANTITY	EQUIPMENT	UNIT OF MEASURE	UNIT COST	QUANTITY	DAILY SUBTOTALS	ANNUAL SUBTOTALS
Mobilization and Preparatory Work (WBS 33.1.01)							**$62.38**	**$12,475.88**
Physician Fees							*$8.40*	*$1,680.88*
	Technical Staff Member	2		Hour	$48.00	4	$1.92	$384.00
	Health Physicist	1		Hour	$80.00	4	$1.60	$320.00
	Supervisor	2		Hour	$90.86	4	$3.63	$726.88
	Physician			Lump	$50.00	5	$1.25	$250.00
Ear Mic Equipment							*$53.98*	*$10,795.00*
			Ericson Radio (Model M-RK)	Lump	$1,048.00	5	$26.20	$5,240.00
			Custom Ear Mics/PTT Switch/Cable	Lump	$925.00	5	$23.13	$4,625.00
			Antenna	Lump	$10.00	5	$0.25	$50.00
			Single Charger	Lump	$60.00	5	$1.50	$300.00
			Metal Belt Clip	Lump	$21.00	5	$0.53	$105.00
			High Capacity Batteries	Lump	$95.00	5	$2.38	$475.00
Monitoring, Sampling & Testing (WBS 33.1.02)							**$2,582.38**	**$516,476.76**
Crate Sampling							*$2,205.58*	*$441,116.76*
	Technical Staff Member	2	Crate Production	Hour	$48.00	1000.00	$480.00	$96,000.00
		2	Don PPE and enter work zone	Hour	$48.00	100	$48.00	$9,600.00
		2	Dof PPE and exit work zone	Hour	$48.00	133.50	$64.08	$12,816.00
	Health Physicist	1	Crate Production	Hour	$80.00	1000.00	$400.00	$80,000.00
		1	Don PPE and enter work zone	Hour	$80.00	100	$40.00	$8,000.00
		1	Dof PPE and exit work zone	Hour	$80.00	133.00	$53.20	$10,640.00
	Supervisor	1	Crate Production	Hour	$90.86	1000.00	$454.30	$90,860.00
		1	Don PPE and enter work zone	Hour	$90.86	100.00	$45.43	$9,086.00
		1	Dof PPE and exit work zone	Hour	$90.86	133.00	$60.42	$12,084.38
	Supervisor	1		Hour	$90.86	1233.00	$560.15	$112,030.38
PPE							*$376.80*	*$75,360.00*
			Tyvek Coverall	Ea.	$6.00	1600	$48.00	$9,600.00
			Tyvek Hood	Ea.	$0.84	1600	$6.72	$1,344.00
			Latex Overboots	Pair	$3.30	1600	$26.40	$5,280.00
			PVC Overboots	Pair	$12.15	1600	$97.20	$19,440.00
			Glove Liners	Pair	$3.76	1600	$30.08	$6,016.00
			Gloves N-DCR	Pair	$0.20	1600	$1.60	$320.00
			Gloves Nitril/Latex	Pair	$1.35	1600	$10.80	$2,160.00
			Respirator Cartridge	Set	$8.00	1600	$64.00	$12,800.00
			Respirator Cleaning	Ea.	$250.00	48	$60.00	$12,000.00
			PPE Laundry Service Fee	Unit	$4.00	1600	$32.00	$6,400.00
Demobilization (WBS 33.1.21)							**$0.00**	**$0.00**
							$0.00	$0.00
							$0.00	$0.00
TOTAL COST:							**$2,644.76**	**$528,952.64**

APPENDIX C

ACRONYMS AND ABBREVIATIONS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
dBA	Decibels (Acoustic)
DOE	U.S. Department of Energy
D&D	Decontamination and Decommissioning
HTRW RA WBS Structure	Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown
ICT	Integrating Contractor Team
IHT	Industrial Health Technician
ITSR	Innovative Technology Summary Report
LANL	Los Alamos National Laboratory
LSDDP	Large-scale Demonstration and Deployment Project
NASCAR	National Association of Stock Car Auto Racing
NETL	National Energy Technology Laboratory
OST	Office of Science and Technology
PPE	Personal Protective Equipment
RCT	Radiation control technician
RPS	Radiation Protection Systems
TMS	Technology Management System
TWISP	Transuranic Waste Inspectable Storage Project
WBS	Work Breakdown Structure